Lake Erie
Fisheries Assessment Unit
Report 1986-2

Evidence of Yellow Pickerel (Stizostedion vitreum vitreum) Reproduction in the Central Basin of Lake Erie, 1985

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TABLE OF CONTENTS

	Page
ABSTRACT	iii
INTRODUCTION	1
DESCRIPTION OF THE STUDY AREA	2
METHODS	
Occurrence of Maturing, Ripe and Spent Walleye	4
Occurrence of Walleye Eggs	5
Sampling Logistics:	5
Egg Identification:	7
Occurrence of Larval Walleye	9
Occurrence of Juvenile Walleye	11
Beach Seining:	11
Bottom Trawling:	13
RESULTS AND DISCUSSION	
Occurrence of Maturing, Ripe and Spent Walleye	16
Occurrence of Walleye Eggs	18
Spatial Distribution of Eggs:	18
Egg Identification:	19
Occurrence of Larval Walleye	22
Occurrence of Juvenile Walleye	22
Beach Seining:	22
Bottom Trawling:	23
CONCLUSION	23
RECOMMENDATIONS	24
ACKNOWLEDGEMENTS	26
REFERENCES	27
TABLES	30
APPENDICES	39

ABSTRACT

To determine if yellow pickerel (walleye) (Stizostedion vitreum vitreum) were reproducing in the eastern part of the central basin of Lake Erie, a study was conducted in 1985 to document the occurrence of maturing, ripe and spent walleye followed by sampling designed to detect walleye eggs, larvae and juveniles at selected sites.

During the spawning period, limited numbers of maturing, ripe and spent walleye were observed in the landed commercial gillnet catch from throughout the study area which stretched from Patrick Point to Port Bruce. Large numbers of spent walleye were observed on board commercial fishing vessels after the spawning period. More than half of the female walleye were estimated to have spawned by April 29. The highest concentrations of spent walleye were found in the Patrick Point-Plum Point area. Although the presence of walleye eggs was suspected, none were positively identified from eggs collected during the sampling period between May 7 and May 25. No larval walleye were captured during the larval fish sampling period from May 16 to June 20. No young-of-the-year juvenile walleye were captured during the juvenile sampling period from June 24 to September 4.

INTRODUCTION

In recent years, the commercial harvest of yellow pickerel (walleye) has increased in the central basin of Lake Erie (MNR 1984) leading to speculation that there has been a re-establishment of a central basin spawning population. Historically the inshore waters between Wheatley and Erieau were considered by commercial fisherman to be a minor spawning area (Krause 1967; Tiessen 1967).

In 1984, the Lake Erie Fisheries Assessment Unit (LEFAU) initiated a study to determine if walleye were reproducing in the western part of the central basin of Lake Erie (Timmerman and Dunlop 1985). The study was designed to collect evidence of reproduction by documenting the occurrence of maturing, ripe and spent walleye followed by sampling designed to collect walleye eggs, larvae and juveniles. The 1984 study indicated there appeared to be some degree of reproductive success in the vicinity of Erieau.

This work was an extension of the study initiated in 1984. While the 1984 study was conducted in the central basin from Erieau to the Patrick and Plum Points area, the present study surveyed the area from Patrick Point to Port Bruce.

DESCRIPTION OF THE STUDY AREA

The study area was confined to part of the Canadian waters of Lake Erie's central basin (Figure 1). The study area was bounded on the west by waters in grid locations 2263, 2253, 2243, 2233, 2213 and 1293 and on the east by waters in grid locations 2279, 2269, 2259, 2249, 2239 and 2229 (Lake Erie Grids for Fisheries Data Base). Each grid measured five minutes of latitude by five minutes of longitude (9.2 x 6.8 km) covering an area approximately 63 km^2. The study area was almost entirely within fishery statistical district OE-3 with a small portion in statistical district OE-2 (Smith et al 1961).

Except for small areas of beach or dune complex at Port Talbot, Port Stanley and Port Bruce, the shoreline consists of bluffs higher than 3 meters (Haras and Tsui 1976). The shoreline is susceptible to high erosion rates from wave action because it consists of high clay bluffs with little beach protection (Gelinas and Quigley 1973). The lowest erosion rates in the study area are found near Patrick and Plum points where there is less wave action and the bluffs are composed of coarser sand and gravel tills. The highest erosion rates occur along the bluffs to the east of Port Stanley where the presence of easily eroded sands and tills extend to lake level.

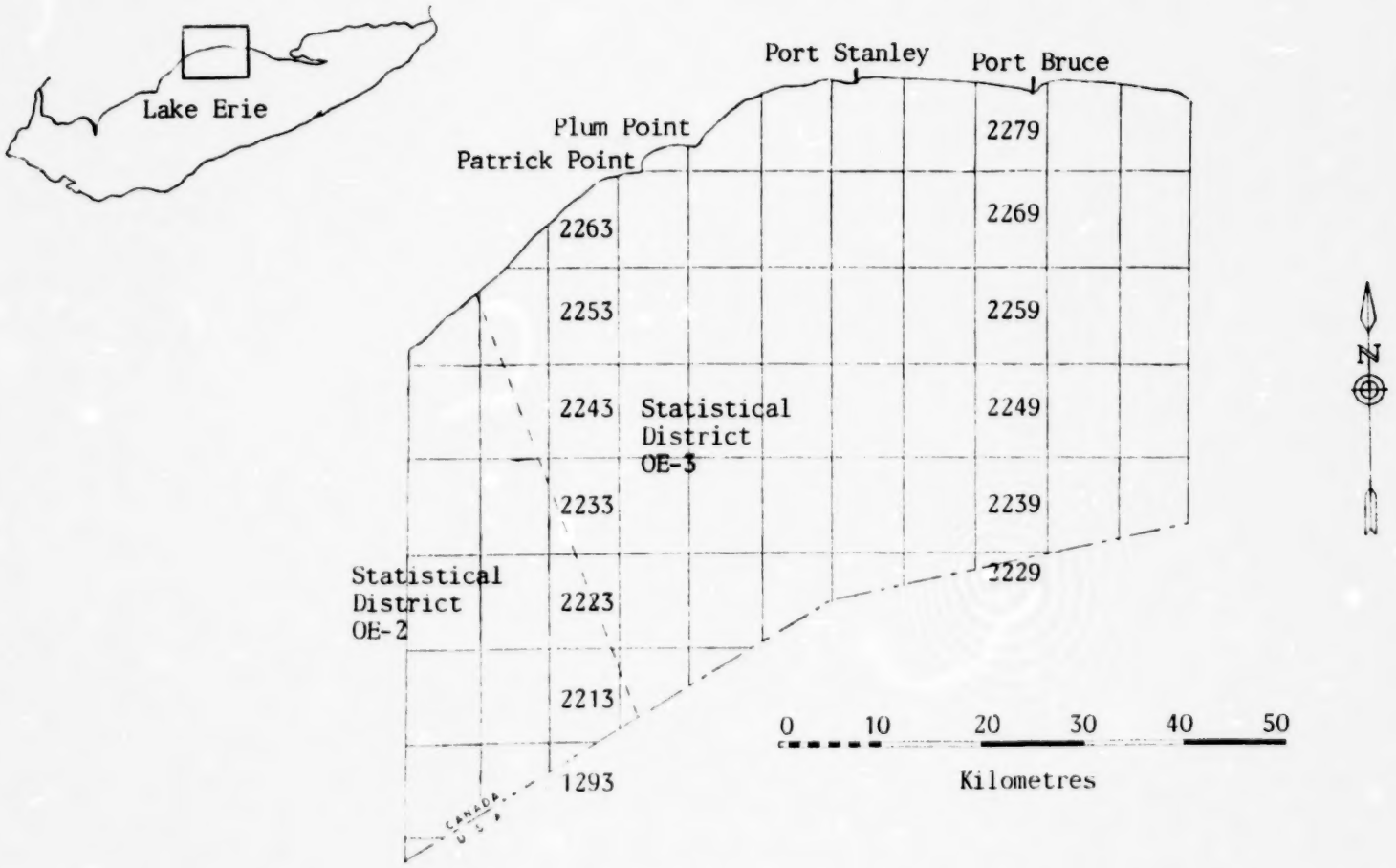

Figure 1. The study area.

METHODS

Occurrence of Maturing, Ripe and Spent Walleye

Several methods were used to obtain information on the occurrence of maturing, ripe and spent walleye. Between April 17 and May 9, 1985, 439 walleye were sampled randomly from the landed catches of commercial gillnet fisherman at Port Stanley. When available, up to 40 walleye were sampled from each catch. From May 5 to May 9, 1985, 247 walleye were sampled on board fishing vessels working out of Port Stanley. In the latter case, samples were not random but larger fish, those more likely to be mature, were chosen for examination. In both cases scale samples were taken and length measurements, sex and sexual maturity were recorded for each fish. When permitted, the gonads were examined and sex and sexual maturity determined using criteria described by Eschmeyer (1950). Otherwise, sex and maturity was determined by expulsion of milt or eggs and fish were classified as being:

unknown - fish with hard gonads, gonadal products not free-flowing;

ripe - fish with free-flowing gonadal products; or

spent - fish with soft gonads and only residual gametes visible.

Additional information concerning concentrations of ripe and spent walleye and their estimated spawning dates was obtained from interviews with commercial fishermen and Ministry of Natural Resources port observers at Port Stanley.

Catch location was provided by the boat captain and was expressed as a number representing a grid for the Lake Erie Fisheries Data Base.

Occurrence of Walleye Eggs

Sampling Logistics:

Based on the time of spawning estimated from the examination of mature walleye, egg collection was conducted from May 7 to May 24, 1985. A total of 24 samples were collected at 12 sampling sites in nearshore waters from Patrick Point (latitude 42°35'00", longitude 81° 27'59") in the west to near Port Bruce, Elgin county (latitude 42° 39'25", longitude 81°01'22") in the east (Figure 2) (Appendix I).

Sample site selection was determined by the location of maturing, ripe and spent walleye encountered earlier in the study, by comments from commercial fishermen and by substrate suitability. The area near Patrick Point had yielded commercial walleye catches during the spawning season in the past (A. Grayling pers. comm.) and yielded the largest number of fish eggs in the previous study (Timmerman and Dunlop 1985). L. Jackson (pers. comm.) also suspected suitable walleye spawning substrate (i.e. gravel) in the Patrick Point-Plum Point area as well as near Port Bruce. Sample site selection was also made in a systematic fashion to cover the entire study area.

Port Stanley (latitude 42°39'48", longitude 81°12'50") was used as an operations base for both the egg collecting and larval fishing phases of the study because of its central location. A charter boat operator was hired because of his knowledge of the local waters, his familiarity with the project from the previous study and the suitability of his boat for the work. The boat was a 12-m steel hulled vessel.

Egg samples were collected using a Goulds Model 3677 Utility Pump (Series DU) powered by a 2.2 kW Briggs and Stratton motor with a flow rate of 500 l/min. The pump was fitted with varying lengths of 5.1-cm inside diameter flexible irrigation hose. The intake end of the hose

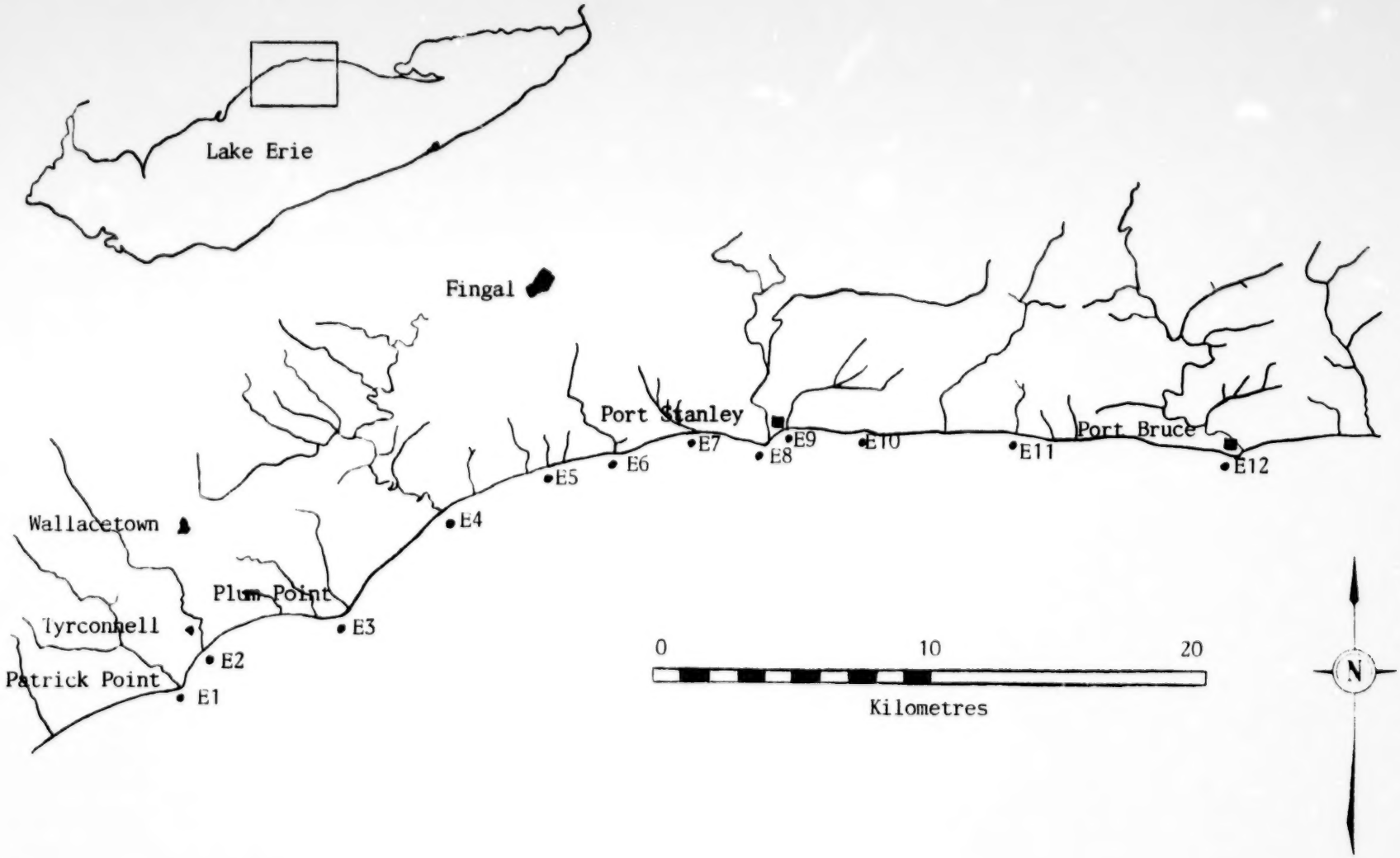

Figure 2. Fish egg collection sites in the central basin, Lake Erie, 1985.

was equipped with a slotted screen with openings of 39 x 7 mm and a length of heavy duty chain to weigh it down. Each sample consisted of materials separated from the pump effluent during a ten-minute sampling period. The operating pump was moved along a transect beginning in water 2 - 4 m deep and proceeding offshore perpendicular to the shore line. Because suggestions were made that walleye may be spawning in water deeper than that which was sampled in the 1984 study, egg collections were made in waters up to 15.2 m deep. The intake hose was dragged along the substrate at speeds of 1.6 - 3.2 kmph while the effluent was strained through two nested screens 45.7 cm sq x 11.4 cm deep. The upper screen measured 8 meshes to 2.54 cm while the lower screen measured 14 meshes to 2.54 cm. Pumped material and echo sounder tracings provided an indication of substrate type. Bottom water temperatures were taken at the pump effluent with a hand-held thermometer.

All eggs and benthic invertebrates were removed from the screen and the percent of live eggs was estimated. Translucent eggs and those exhibiting embryonic development were considered live, while opaque and fungus covered eggs were considered dead (Eschmeyer 1950; Johnson 1961; Manz 1962).

Egg Identification:

Savoie (1984), Timmerman and Dunlop (1985) and possibly others recognized the need to distinguish between walleye and trout-perch (Percopsis omiscomaycus) eggs (and possibly others) which are similar in appearance and likely to occur on similar bottom types at the same time of the year. Extensive efforts were made to identify the eggs collected.

Live eggs from several samples were incubated to identify hatched

fry. Eggs were kept in lake water at ambient lake water temperatures until they were placed in one of two types of incubators. Initially, eggs were placed in jars at the Wheatley Water Plant, near Wheatley, Ontario where a steady supply of unfiltered, unchlorinated lake water was passed over them. To prevent any larval fish which may hatch from being swept over with the overflow, the mouths of the jars were covered with 2-mm mesh door screen. When this method proved unworkable, eggs were brought to the laboratory and placed in jars filled with lake water which was aerated with an aquarium pump and airstone. These jars were placed in a water bath between 13.5 and 16.0^{o} C. The temperature of the bath was controlled by regulating the volume of water flowing into the bath. To control the growth and spread of the fungus Saprolegnia, eggs were bathed in a 1:600 formalin bath for 15-30 minutes immediately after being collected and once a day thereafter (L. Witzel, pers. comm.). Eggs were observed daily to detect hatching and to remove dead and/or fungus covered eggs.

Dead eggs and live eggs which were not kept for hatching were immediately preserved in 5% formalin. The low concentration of formalin prevents shrinking, so that measurements of diameter give reliable data for egg identification (Bagenal and Braum 1978). All eggs from each sample which were undamaged and not covered with fungus were measured together in an egg trough. A mean egg diameter for all measurable eggs from each sample and a weighted mean diameter for all measurable eggs collected from all sites throughout the sampling period was calculated.

A detailed examination of eggs was made using a Leitz-Wetzlar binocular dissecting microscope. Eggs were also submitted to the National Museum of Natural Sciences, Ottawa, to confirm their identification.

Occurrence of Larval Walleye

Based on the observed maturity of sampled adult walleye, and a reported hatching time of 12-18 days (Scott and Crossman 1973), larval fishing was scheduled for two days a week from May 16 to June 20, 1985. A total of 82 tows were made at 11 sites in nearshore waters from Patrick Point (latitude 42°35'00", longitude 81°27'59") in the west to as far east as Port Bruce (latitude 42°39'25", longitude 81° 01'22") (Figure 3) (Appendix II). Sites sampled were generally the same as those sites sampled with the egg pump.

The fishing gear was identical to that used in the 1984 study (Timmerman and Dunlop 1985). It consisted of a 3.35-m long conical net attached to a steel ring with an inside diameter of 1.00 m making the effective fishing area 0.785 m^2. The net tapered to 7.62 cm at its distal end which had a PVC coupling attached to it. The cod end consisted of a 22-cm length of 7.62-cm PVC pipe capped with a plexiglass disk and was attached to the net by screwing it into the PVC coupling. The 1.0-l capacity cod end had screen-covered straining windows cut into the pipe wall. The net and straining windows of the cod end were made of 526 µ mesh size nylon monofilament cloth. A 4.9-kg depressor foil, which was attached to the bottom of the steel ring, maintained the net opening in a vertical position when fishing. The net was towed from a boom protruding laterally from the boat to avoid the effect of propeller and boat turbulence on fish.

Surface, midwater and bottom tows were made at water depths ranging from 1.8 to 13.7 m. Depth of the net in the water column was determined by the length and angle of the tow line. In water deeper than 6 m, chains were tied to the bottom of the steel ring to bring the net down. For surface tows, the net was equipped with two 16.8 x 19.0-cm Spongex floats fastened near the top of the steel ring. With

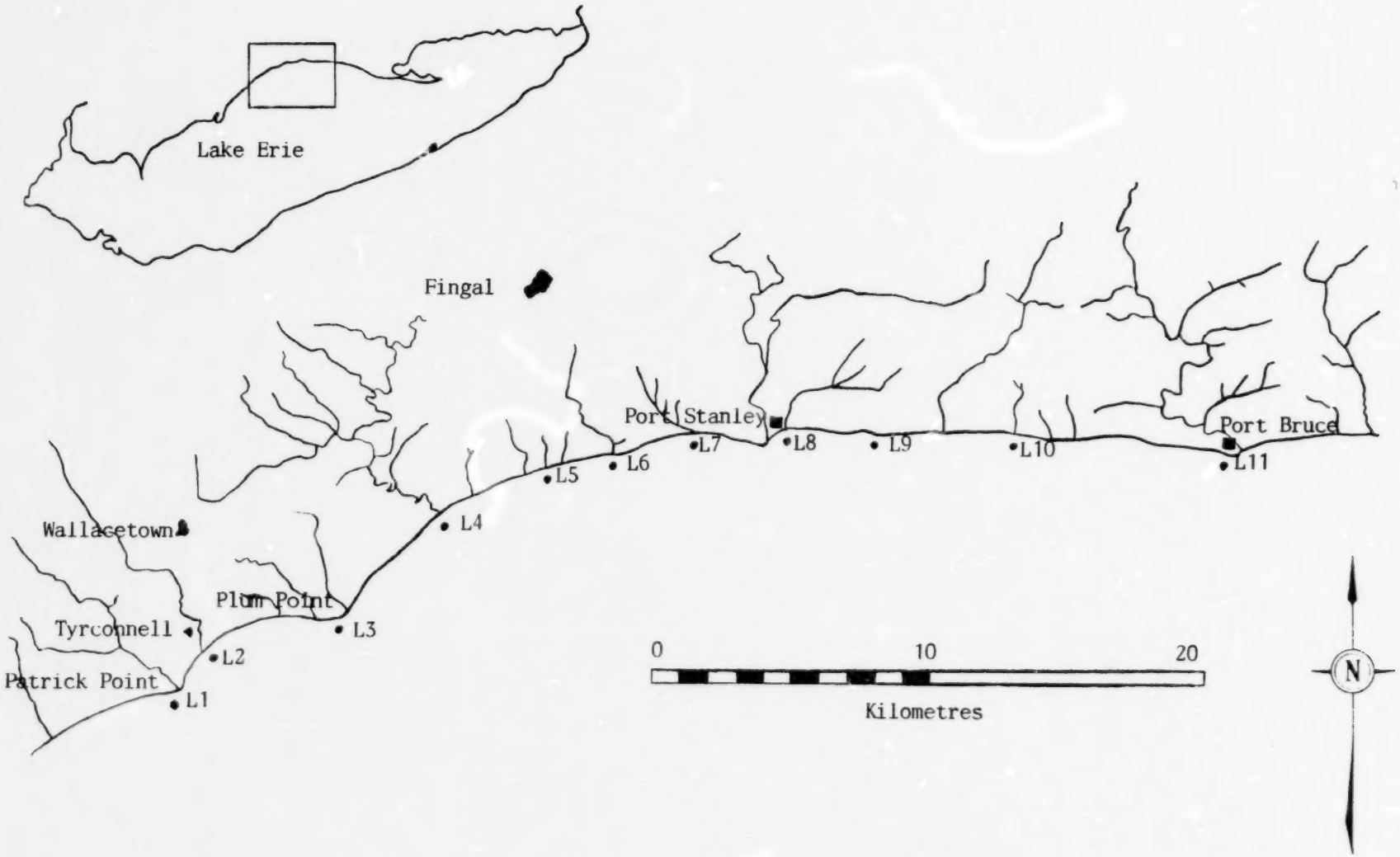

Figure 3. Larval fish collection sites in the central basin, Lake Erie, 1985.

these floats, the net fished the top 0.67 m of the water column while it was towed behind the boat. The net was towed at least 30 m behind the boat to avoid the effect of noise and turbulence on fish.

All tows were five-minutes long and were made parallel to shore at a boat speed of approximately 1 m/sec. Water depth was recorded from the echo sounder at each site and surface water temperature was taken with a hand held thermometer. On those days when egg collections were carried out at the same site, bottom water temperatures were available for bottom tows.

After each tow, the net was washed down with water and the collected material was fixed in 5-10% formalin. Later, larval fish were sorted from plankton and algae and preserved in 5% unbuffered formalin (D. Faber, pers. comm.). Specimens were identified and counted at the National Museum of Natural Sciences, Ottawa.

Occurrence of Juvenile Walleye

Two techniques were employed to detect the occurrence of juvenile walleye: beach seining and bottom trawling.

Beach Seining:

As the season progressed, the increasing intensity of plankton blooms interfered with the plankton net's efficiency to catch larval fish. Priegal (1970) found that as fry increased in size, their ability to avoid a meter net increased and they were not easily captured especially when the net was not fishing efficiently because of zooplankton blooms. Young walleye would also be expected to be growing and after leading a pelagic existence after hatching, young walleye undergo a transition to an inshore, demersal mode (Eschmeyer 1950; Johnson 1969; Bulkley et al 1976; Forney 1976; Ryder 1977). Consequently, beach seining was used to attempt the capture of

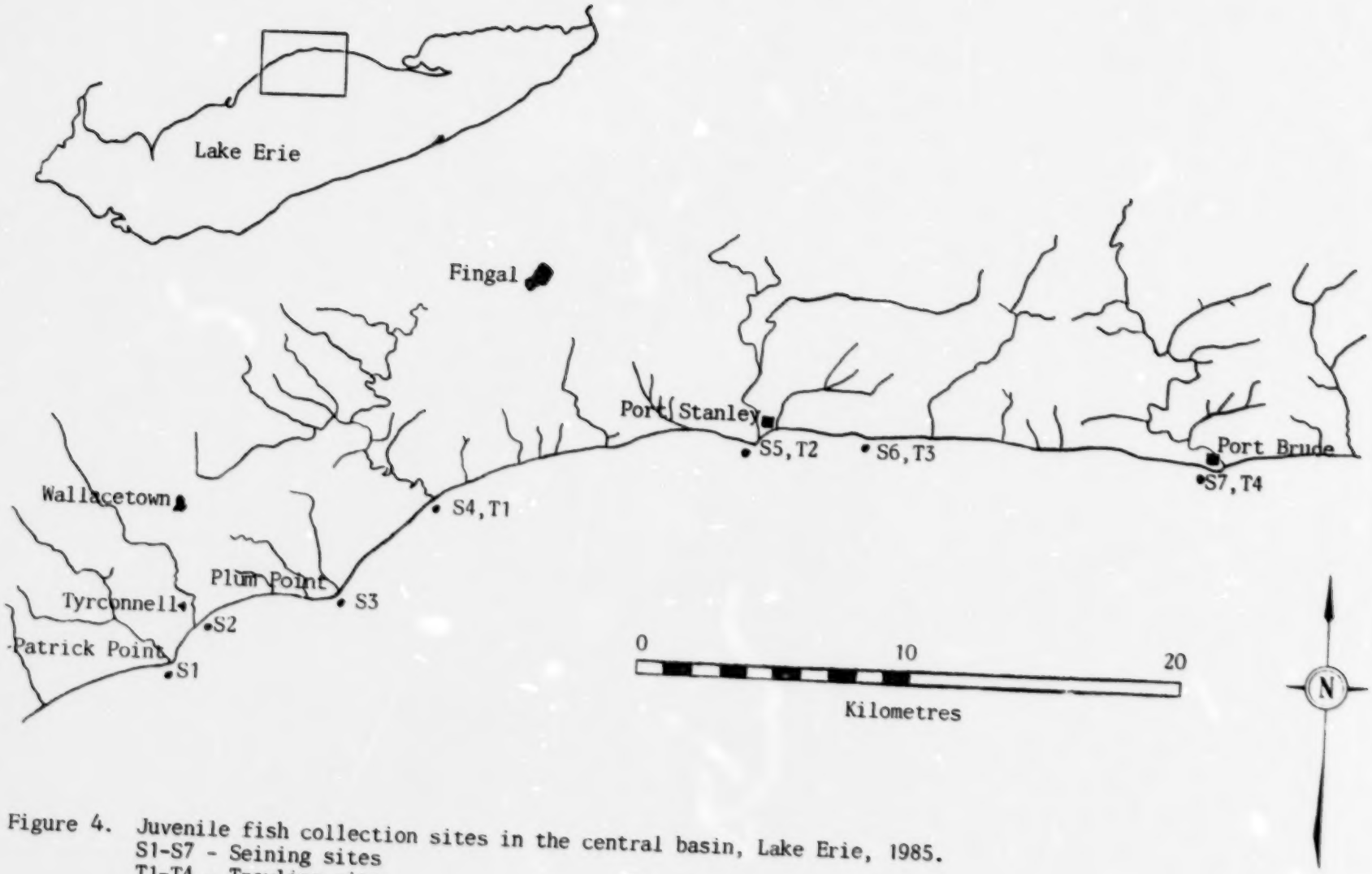

Figure 4. Juvenile fish collection sites in the central basin, Lake Erie, 1985.
S1-S7 - Seining sites
T1-T4 - Trawling sites

juvenile walleye from June 25 to July 30, 1985.

A total of 38 seine hauls were made at the few sites within the study area which were accessible and physically suitable for beach seining (Figure 4) (Appendix III). Based on the results of the previous study, the boat-set seining method was used as it allowed for sampling of larger areas and deeper water than the hand-set method of seining (Timmerman and Dunlop 1985). An 18.3-m long by 2.1-m deep nylon seine net with a mesh size of 0.56-cm stretched measure was used. The seine was designed to fish on the bottom in water depths greater than the depth of the seine (2.1-m). Lengths of rope 30.5-m long were tied to each end of the seine. Using a 4.3-m aluminum boat with the aid of a 7.1-kW outboard motor or oars, the seine was set out parallel to the shore and 30.5 m offshore. Both ends of the seine were drawn in simultaneously to the beach by hand. Maximum water depth, substrate type and inshore surface water temperature were recorded with each seine haul.

Each site was scheduled to be sampled once weekly. Normally only one seine haul was made at each site on each sampling day, however if time permitted, a site was sampled twice. If the water was too rough to seine effectively, the site was omitted on that day. All seining was done in daylight hours.

Captured fish were identified and enumerated. Seine hauls yielding large numbers of fish were subsampled. Species difficult to identify were preserved in 10% formalin for later identification. Young-of-the-year (YOY), yearling (YRLG) and older age classes were estimated by length and enumerated separately where applicable.

Bottom Trawling:

Several authors (Maloney and Johnson 1955; Forney 1966; Johnson 1969) have observed a gradual offshore migration of YOY walleye into

deeper water as the summer progresses. Priegal (1970) and Forney (1976) found that once walleye had attained a length of 35 mm, they could be captured by bottom trawling in open water areas of lakes. This is consistent with the findings of Bulkowski and Meade (1983) who found that under laboratory conditions, walleye at 9 weeks of age (30 - 35 mm long) could be described as negatively phototactic and presumably would seek waters of decreasing light intensity. Consequently, bottom trawling was carried out from August 8 to September 4, 1985.

A total of 44 trawls were made with the outboard trawl at four sites (Figure 4) (Appendix IV). During the 1984 survey, attempts to trawl in areas adjacent to the clay bluffs which dominate the shoreline in the study area proved unsuccessful as the net fouled on irregular substrate (Timmerman and Dunlop 1985). In 1985, bottom trawls were attempted only in areas adjacent to sand or gravel beaches that were within an hour, by water, of a boat launching facility at Port Stanley. The depth sounder on the boat helped in locating flat-bottomed, obstacle-free areas suitable for bottom trawling.

Sampling was done with a bottom trawl having a head rope length of 6.1 m, with a mouth opening of 1.0 m in height and made of 3.8-cm stretched mesh nylon web with a 1.3-cm stretched mesh cod end. The trawl was pulled 46 m behind a 6.1-m fiberglass boat powered by a 140-kW inboard-outboard engine at a water speed of approximately 4.5 km/hr. All trawls were five-minutes in duration and were made parallel to the shore.

Each site was scheduled to be sampled once weekly. Each sampling consisted of up to three trawls with the first, second and third trawls in about 3 m, 6 m and 9 m of water respectively. Trawling was abandoned on days when water conditions became too rough to fish

effectively.

The water depth, obtained from the depth sounder, and the bottom temperature, obtained with a Fish Hawk Model 520 hand-held thermistor were recorded before each trawl. Captured fish were identified and enumerated. Age classes, estimated from length, were enumerated separately where applicable.

RESULTS AND DISCUSSION

Occurrence of Maturing, Ripe and Spent Walleye

All 439 walleye sampled from the landed catches of commercial fishermen were caught in "canned" nets (gill nets suspended off the lake bottom) in an area from south of Plum Point (grid 2275) to an area south of Port Bruce (grid 2279) (Figure 5). Of the 72.4% of the walleye which were able to be sexed, the majority (93.7%) were females (Table 1), and of these only 3.7% were mature (Table 2). Seven year-classes (ages two through eight) were represented with the 1982 year-class (age 3) dominant. All males were mature by age two. Females at age two, three, four and five were 0.0%, 1.5%, 16.7% and 100.0% mature respectively.

The scarcity of mature fish in the landed catch along with information obtained from Ministry of Natural Resources personnel, commercial fishermen and other individuals led us to believe that the larger mature walleye were not being landed. Direct observations and on-board sampling substantiated this belief.

All 247 walleye sampled on board commercial fishing vessels were caught in "canned" nets in an area from southwest of Patrick Point (grid 2253) eastward to an area southwest of Port Stanley (grid 2266) (Figure 5). Again females were dominant, probably as a result of selection of larger fish for sampling (Table 3). Samplers on board fishing vessels noted that these larger mature walleye constituted a "substantial" portion of the catch. Virtually all of the females were spent by the time sampling was initiated. Seven year-classes (ages three through nine) were represented with no year-class appearing to be dominant (Table 4). All females were mature by age three.

Other information obtained from conversations with Ministry of Natural Resources port observers, and commercial fishermen concerning

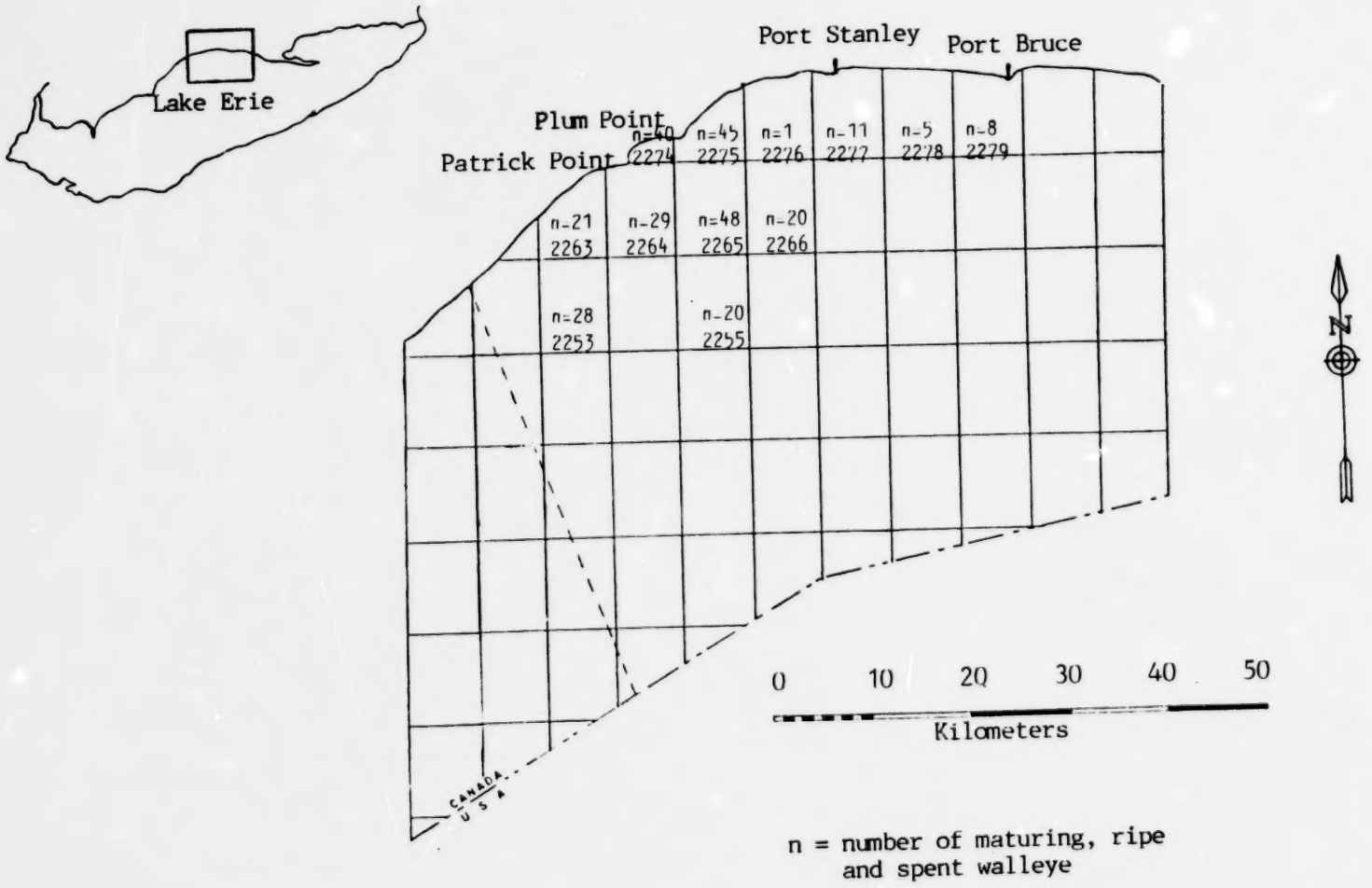

Figure 5. Capture site (grid location number) and numbers of maturing, ripe and spent walleye sampled from landed commercial catches and on board commercial fishing vessels in the central basin, Lake Erie, 1985.

concentrations of ripe and spent walleye and their estimated spawning dates is presented in Appendix V. These comments further substantiated the belief that walleye in various stages of sexual maturity including ripe and spent were present in the study area during the spawning season. Based on this information, more than half of the female walleye had spawned by April 29 and by May 1, 1985, most were spent.

Maturing and ripe walleye sampled prior to the spawning period were caught in grids 2277, 2278 and 2279. The highest concentrations of spent walleye sampled after the spawning period were found in the waters off Patrick and Plum Points (Figure 5).

Occurrence of Walleye Eggs

Spatial Distribution of Eggs:

Fish eggs were present in 20 of the 24 samples collected with the egg pump and numbers of eggs per sample ranged from 0 to 122 (Table 5).

Shallow water samples consistently yielded more eggs than deeper water samples (Table 5). Samples containing 30 or more eggs were taken in water depths between 2.7 and 6.1 m while few eggs were taken in depths greater than 10.4 m.

The largest numbers of eggs were taken at sites E3, E6 and E10 (Table 5) (Figure 3). Site E3 (Plum Point) which contained the largest number of eggs in any one sample is characterized as having substrate composed of gravel, rubble and boulders. This site was also one of the two sites containing the greatest number of eggs in 1984 (Timmerman and Dunlop 1985). In addition, the Patrick Point-Plum Point area corresponds to a section of the central basin shoreline with the lowest erosion rates and the least wave action (Gelinas and

Quigley 1973). Eschmeyer (1950) and Johnson (1961) have reported that in lakes, isolated areas of gravel and rubble are desired walleye spawning substrates. Sampling depths at Plum Point and Patrick Point (E1) which also contained a large number of eggs, ranged from 2.7 to 6.1 m. In the western basin of Lake Erie, Baker (1971) found the largest numbers of walleye eggs in water depths less than 4.6 m over rocky bottom. The combination of desirable substrate, preferred water depths and reduced wave action in this area would suggest that it is desirable spawning habitat for walleye.

Sites E6 and E10 which also yielded large numbers of eggs in water depths less than 6.1 m are characterized by substrate of clay, sand and gravel. Both Eschmeyer (1950) and Johnson (1961) found that walleye would also spawn over this type of substrate when gravel-rubble substrate was not available. Johnson (1961) however found that egg survival was best on clean gravel-rubble bottom, intermediate on firm clean sand bottom and poor on soft muck-detritus bottom. It is also possible that eggs may have been transported to these less desirable substrates by wind and wave action, an observation noted by both Eschmeyer (1950) and Johnson (1961).

Egg Identification:

The percentage of live eggs ranged from 31% to 80% for those samples containing more than ten eggs. Olson (1966) noted that it is often difficult to distinguish dead infertile eggs from fertilized ones during the first four days of parthenogenic development and these values should therefore be considered estimates. Many of the eggs were covered with fungus.

Attempts at incubating eggs were largely unsuccessful. Most of the eggs became invaded with fungus despite the daily treatments with

the 1:600 formalin bath. A larva was hatched in the laboratory on May 17 from one of three eyed eggs collected on May 16 at site E9, but could not be identified. The other two live eggs from this sample died, however the embryo inside one of these eggs was identified as a trout-perch.

Two large eggs (4 mm diameter) with no oil globule were found in one sample at site E9 and were presumed to be sucker (Catostomus sp.) eggs. The mean egg diameters for all other measurable eggs from each sample ranged from 1.9 to 2.2 mm and the weighted mean diameter for all eggs from all samples was 2.07 mm. These egg diameters compare favourably with egg diameters of walleye reported in the literature. Nepszy (pers. comm.) found "fresh" walleye eggs from the Thames River had a mean diameter of 1.98 mm (range 1.89 - 2.11 mm), Carpenter (1939) reported walleye eggs from the western basin of Lake Erie to be 2.16 mm in diameter and McElman and Balon (1979) found that eggs from walleye from the Talbot River in Ontario had a mean diameter of 2.09 mm after hydration.

Trout-perch also begin to spawn in early May in Lake Erie (Fish 1932) and larvae from this species were hatched from eggs collected during the 1984 study (Timmerman and Dunlop 1985). Fish (1932) describes freshly spawned trout-perch eggs from Lake Erie to range from 1.4 to 1.9 mm in diameter after fertilization. This places them within the range of walleye egg diameters reported in the literature and within the range of egg diameters found in this study (1.9 to 2.2 mm). We found however that the eyed eggs collected in the present study (one of which was subsequently identified as a trout-perch egg) appeared to be noticably larger than most of the other eggs.

In addition to having size ranges that overlap, walleye and trout-perch eggs are also similar in morphology, both having a single

large oil globule between 0.60 and 0.77mm after fertilization (Auer 1982; McElman and Balon 1979; Carpenter 1939; Fish 1932). Microscopic examination of the eggs collected in this study revealed that a single large oil globule was visible in most of the eggs suggesting that they were either walleye eggs or trout-perch eggs.

With the exception of three eyed-eggs collected on May 16 at site E9 (one of which was subsequently identified as a trout-perch egg) and two eyed-eggs collected on May 22 at site E5, all of the eggs were in early stages of development.

W.L. Hartman (unpubl.) found a straight line relationship between the length of the incubation period for walleye eggs and the average incubation temperature ($Y = -5.481 + 1.062X$) where $100/Y$ is the incubation period, and X is the average incubation temperature (from Colby et al. 1979). Based on a median spawning date of April 29 and an average incubation temperature of 10.55° C (obtained from Elgin Area Water System), the incubation period was estimated to be approximately 17.5 days and the time of mid-hatching was estimated to be May 16. Walleye eggs, had they been present in the samples, would have been expected to be in various stages of development during the course of the sampling period from May 7 to May 24. Although measured eggs were within the size range expected for walleye eggs, the confirmation of at least one trout-perch egg in the samples and the predominance of eggs in early stages of development only suggest that trout-perch eggs and possibly eggs of other species were also present in the samples. Similarities between walleye eggs and trout-perch eggs in terms of both diameter and morphology make it difficult to differentiate these eggs in samples.

Until embryos from eggs in late stages of development can be positively identified or eggs can be incubated to hatching, there is

only circumstantial evidence of walleye egg deposition at the sites investigated in this study.

Occurrence of Larval Walleye

An estimated total of 805 larval fish were caught with the larval net (Table 6). Rainbow smelt (Osmerus mordax), yellow perch (Perca flavescens) and trout-perch contributed 86.3%, 6.8% and 3.2% by numbers of the total catch respectively. The remaining 3.6% consisted of Morone sp., members of the clupeidae family and unidentified fish. No larval walleye were captured.

Occurrence of Juvenile Walleye

Beach Seining:

During seining operations, inshore surface water temperatures ranged from 15.0 to 23.5^{o}C and the maximum water depth seined was 3.4 m. The percent catch composition for seine net hauls for all seven seine sites combined is presented in Table 7. The number of fish and species composition per seine haul varied with weather and water conditions as well as the location of the site. Of the twenty-one species of fish captured, no YOY walleye were caught. However, on July 2 at site S4 (Port Talbot), three YRLG walleye were captured in water less than 1.9 m deep. Their mean total length was 193 mm (range 173 - 206 mm). These walleye may have moved with water currents from a more westerly location. Ferguson and Derksen (1971), through tagging studies, demonstrated that there was an eastward migration of YOY and YRLG walleye from the west basin to the central basin during the summer. The absence of YOY walleye in seine net hauls indicated that they may have reached a length where they could be inhabiting deeper water.

Bottom Trawling:

Water depths sampled with the outboard trawl ranged from 1.5 to 10.1 m. Bottom water temperatures during trawling operations ranged from 15.5 to 24.0^{o} C. Table 8 presents the results of trawling procedures used to attempt the capture of juvenile walleye in deeper water. Percent catch composition for all four trawling sites are combined. Of the seventeen species of fish captured no YOY walleye were captured.

CONCLUSION

The occurrence of limited numbers of maturing, ripe and spent walleye in the landed commercial catch and large numbers of spent walleye observed on board commercial fishing vessels suggests that spawning had taken place in the study area. The highest concentrations of spent walleye were observed in the Patrick Point-Plum Point area. More than 50% of the female walleye were estimated to have spawned by April 29. Fish eggs were recovered along the length of the study area. The presence of walleye eggs among those collected was suspected; however, identification was not confirmed as only trout-perch eggs were positively identified in the samples.

No larval or young-of-the-year juvenile walleye were captured in the study area.

Other than the presence of limited numbers of maturing, ripe and spent walleye in the landed commercial catch, the direct observation of large numbers of spent walleye onboard commercial fishing vessels and the suspected occurrence of walleye eggs, no direct evidence of walleye reproduction could be found in the study area.

RECOMMENDATIONS

Based on this study, several recommendations are made to make future studies more effective.

Spawning adults

Future studies should include:

more onboard commercial catch sampling to locate areas of spawning activity more precisely and to derive accurate spawning dates.

Walleye eggs

Future studies should include:

initiation of egg pumping with the first evidence of spawning activity;

preparation of reference collections of fertilized and water hardened walleye eggs and trout-perch eggs at various stages of development;

identification of eggs by incubation and subsequent identification of hatched fry; and

development of a method of accurately measuring individual egg diameters.

Larval walleye

Future studies should include:

initiation of larval fishing based on estimated spawning dates, results of fish egg collections and water temperatures; and

discontinuation of sampling when plankton blooms interfere with the plankton net's effectiveness in capturing fish.

Juvenile walleye

Future studies should include:

a sampling schedule based on earlier results;

a larger mesh seine net; and

the use of a larger boat to facilitate easier sampling site access.

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Table 1. Sexual maturity of walleye sampled randomly from landed commercial catches in the central basin, Lake Erie, 1985.

Date	Number examined			Percent							
				Males				Females			
	Male	Female	Sex unknown	Immature	Maturing	Ripe	Spent	Immature	Maturing	Ripe	Spent
April 17	2	8	29[a]	0	100	0	0	100	0	0	0
17	3	8	29[a]	0	67	33	0	100	0	0	0
23	1	38	1	0	100	0	0	95	5	0	0
23	5	33	2	0	100	0	0	94	6	0	0
25	2	38	0	0	50	50	0	100	0	0	0
29	1	39	0	0	100	0	0	100	0	0	0
29	4	36	0	0	100	0	0	100	0	0	0
May 2	0	40	0	-	-	-	-	100	0	0	0
2	2	38	0	0	50	50	0	100	0	0	0
9	0	10	30[a]	-	-	-	-	40	0	0	60
9	0	10	30[a]	-	-	-	-	90	0	0	10
Total	20	298	121								
Percent of total	4.6	67.9	27.6								

[a] no attempt was made to sex these fish.

Table 2. Year-class composition, average total length (mm) and maturity of walleye sampled randomly from landed commercial catches in the central basin, Lake Erie, 1985. Numbers in brackets denote sample size.

Year Class	1983	1982	1981	1980	1979	1978	1977	All
Age	2	3	4	5	6	7	8	
% Comp.	6.4 (28)	86.5 (379)	3.0 (13)	3.2 (14)	0.5 (2)	0.2 (1)	0.2 (1)	100 (438)
Length	394 (28)	435 (379)	486 (13)	561 (14)	608 (2)	540 (1)	609 (1)	(438)
Percent mature males	100 (1)	100 (15)	100 (4)	-	-	-	-	100 (20)
Percent mature females	0 (10)	1.5 (274)	16.7 (6)	100 (6)	0.0 (1)	-	-	3.7 (297)

Table 3. Sexual maturity of adult walleye selected on board commercial fishing vessels in the central basin, Lake Erie, 1985.

Date		Number examined			Percent							
					Males				Females			
		Male	Female	Sex unknown	Immature	Maturing	Ripe	Spent	Immature	Maturing	Ripe	Spent
May	5	0	1	0	-	-	-	-	0	0	0	100
	6	0	20	0	-	-	-	-	0	0	0	100
	6	1	19	0	0	0	0	100	5	0	0	95
	6	1	19	0	0	0	0	100	0	0	0	100
	6	0	28	0	-	-	-	-	0	0	0	100
	7	0	39	1	-	-	-	-	0	0	0	100
	7	1	39	0	0	0	0	100	0	0	0	100
	7	0	20	0	-	-	-	-	0	0	0	100
	7	0	10	0	-	-	-	-	0	0	10	90
	9	0	20	0	-	-	-	-	0	0	0	100
	9	0	20	0	-	-	-	-	0	0	0	100
	9	0	8	0	-	-	-	-	0	0	0	100
Total		3	243	1								
Percent of total		1.2	98.4	0.4								

Table 4. Year-class composition, average total length (mm) and maturity of walleye selected on board commercial fishing vessels in the central basin, Lake Erie, 1985. Numbers in brackets denote sample size.

Year Class	1982	1981	1980	1979	1978	1977	1976	All
Age	3	4	5	6	7	8	9	
% Comp.	0.4 (1)	7.0 (17)	36.9 (90)	20.9 (51)	26.2 (64)	7.0 (17)	1.6 (4)	100 (244)
Length	475 (1)	564 (17)	574 (90)	613 (51)	624 (64)	643 (17)	702 (4)	(244)
Percent mature males	-	-	100 (1)	-	100 (2)	-	-	100 (3)
Percent mature females	100 (1)	100 (17)	100 (89)	100 (51)	98.4 (62)	100 (17)	100 (4)	99.6 (241)

Table 5. Water depths, bottom water temperatures, bottom type and numbers of fish eggs collected at selected sites in the central basin, Lake Erie, 1985.

Site	Date	Sampling depth (m)	Bottom water temp. (°C)	Total number of eggs	Percent live eggs	Bottom type
E1	May 7	3.0-6.1	10.5	40	73	-----
	May 7	11.6-12.2	9.0	2	0	Silt/clay/ gravel
	May 24	3.7-7.9	13.5	2	50	Hard bottom
E2	May 7	3.0-6.4	10.0	4	100	Silt/sand -smooth bottom
	May 24		14.0	5	0	Silt/clay
E3	May 7	2.7-6.1	11.0	122	73	Gravel/rubble/ boulders
	May 24	2.4-7.9	14.5	5	20	Sand/gravel/ boulders hard bottom
E4	May 7	2.7-5.5	11.5	19	42	Sand/very little gravel detritus
E5	May 8	4.0-6.1	10.0	1	0	Silt/clay/sand
	May 22		12.0	15	40	Silt/clay
E6	May 8	10.4	10.0	0	-	Sand/gravel
	May 8	2.7-6.1	11.0	87	64	Clay-very little gravel hard bottom
	May 22	4.6-6.1	12.0	9	56	Silt/clay/ gravel
E7	May 8	2.1-4.6	11.0	6	50	Hard bottom
	May 8	10.4	10.0	0	-	Silt/clay/ gravel
	May 22	2.4-6.1	13.0	16	31	Silt/clay/sand
E8	May 8	2.7-6.1	11.0	10	60	Clay/sand
E9	May 8	10.4-11.0	10.0	0	-	Silt/clay/ sand/gravel
	May 8	3.0-4.3	11.5	30	80	Silt/sand -hard bottom
	May 16	3.0-4.6	16.0	6	100	Sand/gravel
E10	May 8	3.7-6.1	11.5	65	74	Clay/sand -very little gravel
E11	May 16	2.4-4.6	16.0	1	100	Sand/gravel
E12	May 16	14.6-15.2	10.0	0	-	Clay/gravel
	May 16	3.0-4.6	15.0	11	73	-----

Table 6. Water temperatures, water depths and estimated numbers of larval fish captured at selected sites in the central basin, Lake Erie, 1985.

Site	Date	Water depth (m)	Tow depth (m)	Water temp. (°C) Surf.	Bot.	Yellow perch	Rainbow smelt	Trout-perch	Other[a]
L1	May 24	2.7	2.7	19.0	13.5		11		
	June 4	4.6	4.6	13.0		1	13	1	
	June 4	6.1	4.4	13.0			34		1
	June 4	8.5-9.1	0.7						
	June 20	3.7-6.1	1.8	14.0			1		
	June 20	3.4-5.2	3.4	14.0		3	1	4	
	June 20	3.0-6.1	0.7	14.0					
L2	May 24	1.8-3.7	2.7	16.0	14.0		4		
	June 4	3.0	3.0	13.5		1	13		1
	June 4	7.0	3.4	13.5			60		
	June 13	5.8-6.1	6.1	12.0				7	
	June 13	3.0-3.4	1.7-1.9			2	63		
L3	May 24	5.5-6.7	5.5		14.5	1	5		
	May 24	2.1-4.0	2.1	16.0		3	1		
	June 4	7.6-9.1	7.2				9		
	June 4	4.6-4.9	4.6-4.9	14.5		4	10		1
	June 4	4.9	3.4-4.1	14.5			24		
	June 20	3.0-7.0	0.7	14.0					
	June 20	2.4-5.5	1.8	14.0					
L4	May 24	12.2	0.7	15.0					
	May 24	12.2	7.0	15.0			7		
	May 24	3.7-4.0	3.0			1	3		
	May 30	4.0	2.4	14.5					
	May 30	4.0-4.3	4.1						
	May 30	11.0	6.1				3		
	May 30	11.6-11.9	10.4	15.0		2	1		
	June 20	3.0-3.7		15.0			3	1	
L5	May 22	3.7	3.7		12.0	2			
	May 30	4.9	4.9	14.5				1	
	May 30	9.8	9.8	14.5		1	1		
	June 13	3.0-4.9	1.9	11.0			3		
	June 13	4.3-5.8	4.3-5.0	11.0		1	4		
	June 20	4.6-5.8	2.7	14.0					
	June 20	3.0-6.1	0.7	14.0			1		
L6	May 22	4.6	4.0	13.0	12.0				
	May 30	5.2-5.5	5.5					2	
	May 30	9.8-10.4	9.1						3
	June 13	3.0	3.0	11.0		2	2		
	June 13	6.1	6.1					1	
	June 20	4.6	2.2	14.0			1		
L7	May 22	3.7-6.1	0.7	12.0	13.0				
	May 22	4.9	3.0	12.0	13.0	2			10
	May 22	9.1-9.8	0.7	13.0					
	May 30	4.0-4.6	3.7			2	1	1	
	May 30	9.1-9.8	7.0	14.0			2		
	June 13	2.7-4.0	2.3	10.5		1	14		
	June 13	4.6-5.8	3.7				2		
L8	May 29	9.1	4.6	14.5		1	3		
	May 29	3.4-4.0	3.7	15.5		1		2	
	June 5	3.0	2.7	15.5		10	30		
	June 5	7.6-7.9	4.1	16.0			60		1
	June 19	3.0-6.1	0.7	14.0			7		3
	June 19	3.0-3.7	1.8	14.0			2		2
	June 19	3.7-5.2	4.6	14.0			2	1	
L9	May 29	4.0-6.1	3.8	15.5		1			
	May 29	11.0	11.0						
	June 5	4.3-4.6	4.9	16.0		2	5		
	June 5	6.1-6.7	3.5-4.0	16.0			140		
	June 19	4.0-4.9	2.6	14.0			3		
	June 19	4.6-4.9	3.8-4.3	14.0			20	3	
	June 19	3.0-5.2	0.7				14		

Table 6. continued

Site	Date	Water depth (m)	Tow depth (m)	Water temp. (°C) Surf.	Bot.	Yellow perch	Rainbow smelt	Trout-perch	Other
L10	May 16	3.0-5.2	3.7	15.5	16.0				
	May 16	3.0-4.6	0.7	15.5	16.0				
	May 16	10.4	0.7	14.0					
	May 16	7.6	7.3	14.5					
	May 29	2.1-4.3	2.3	15.0		2			
	May 29	4.6-6.1	0.7	15.0					
	May 29	11.6	8.2	14.0			1		
	May 29	11.6	11.6						
	June 5	3.7-4.9	5.2	15.0		1	5		
	June 5	6.1-7.9	4.7	16.5			7		
	June 19	3.7-4.3	4.1	14.0			50	1	
L11	May 16	13.7	0.7	12.5	10.0				
	May 16	3.0-4.6	0.7	15.0					
	May 16	3.0-4.6	3.0-4.6		15.0				
	May 29	4.0-4.6	3.2	14.0		4			7
	May 29	10.4	6.1				1		
	May 29	10.4-10.7	10.4						
	June 5	3.7	3.7	15.0		3	7		
	June 5	8.5	3.4-4.0			1	38		
	June 5	9.1-9.8	0.7	16.0					
	June 19	3.4-3.7	2.9	14.0			3	1	
Total						55	695	26	29
Percent of total						6.8	86.3	3.2	3.6

[a] Includes Morone sp., members of the clupeidae family and unidentified fish species.

Table 7. Percent catch composition by species for seine net hauls at selected sites in the central basin, Lake Erie, 1985. N=25,279

Species	Age Class	Percent
Rainbow smelt	YOY	28.3
Rainbow smelt	YRLG+AD	1.1
White perch	YRLG	27.7
White perch	AD	0.2
White bass	YRLG	0.6
Morone spp.[a]	YOY	1.2
Yellow perch	YOY	0.8
Yellow perch	YRLG	13.5
Emerald shiner	ALL	12.3
Spottail shiner	ALL	1.6
Clupeids[b]	YOY	11.4
Trout-perch	ALL	0.7
Other[c]		0.6

[a] Includes white perch, (*Morone americana*) and white bass, (*Morone chrysops*).

[b] Includes gizzard, (*Dorosoma cepedianum*) and alewife, (*Alosa pseudoharengus*).

[c] Include freshwater drum (*Aplodinotus grunniens*), walleye (YRLG), yellow perch (AD), rock bass (*Ambloplites rupestris*), logperch (*Percina caprodes*), *Cottus* sp., and members of cyprinidae and catostomidae families.

Table 8. Percent catch composition by species for trawls at selected sites in the central basin, Lake Erie, 1985. N=7,288

Species	Age Class	Percent
Rainbow smelt	YOY	45.5
Rainbow smelt	YRLG+AD	8.1
White perch	YRLG	5.5
White perch	YOY	9.7
White bass	YOY	10.1
Yellow perch	YRLG	5.6
Spottail shiner	ALL	1.8
Gizzard shad	YOY	9.1
Trout-perch	ALL	3.3
Other[a]		1.5

[a] Include white perch (AD), white bass (YRLG), yellow perch (YOY), yellow perch (AD), freshwater drum, burbot (Lota lota), channel catfish (Ictalurus punctatus), logperch, Pomoxis sp., alewife, white sucker (Catostomus commersoni) and members of the Cyprinidae family.

Appendix I: Fish egg collection sites in the central basin, Lake Erie, 1985.

Site	Site location	Latitude/longitude
E1	Patrick Point	42°35'00", 81°27'59"
E2	Tyrconnell - off creek mouth	42°35'48", 81°27'18"
E3	Plum Point	42°36'19", 81°23'56"
E4	Port Talbot - off Talbot Creek mouth	42°38'18", 81°21'18"
E5	4.1 km east of Talbot Creek (M^{c}Pherson's Gully)	42°39'09", 81°18'45"
E6	5.5 km west of Port Stanley (Indian Run)	42°39'25", 81°16'56"
E7	2.8 km west of Port Stanley (Grand Canyon)	42°39'50", 81°14'42"
E8	Port Stanley - west of harbour	42°39'35", 81°13'47"
E9	Port Stanley - off Little Creek	42°39'53", 81°12'15"
E10	Hawk Cliff Wildlife Agreement Area	42°39'45", 81°10'14"
E11	8.7 km east of Port Stanley (Lewison's Gully)	42°39'42", 81°06'24"
E12	Port Bruce	42°39'25", 81°01'22"

Appendix II: Larval fish collection sites in the central basin, Lake Erie, 1985.

Site	Site location	Latitude/longitude
L1	Patrick Point	42°35'00", 81°27'59"
L2	Tyrconnell - off creek mouth	42°35'48", 81°27'18"
L3	Plum Point	42°36'19", 81°23'56"
L4	Port Talbot - west of Talbot Creek	42°38'18", 81°21'25"
L5	4.1 km east of Talbot Creek (M^{c}Pherson's Gully)	42°39'09", 81°18'45"
L6	5.5 km west of Port Stanley (Indian Run)	42°39'25", 81°16'56"
L7	2.8 km west of Port Stanley (Grand Canyon)	42°39'50", 81°14'42"
L8	Port Stanley - off Little Creek	42°39'53", 81°12'15"
L9	Elgin Area Water Pumping Station - 200 m west of pump house	42°39'45", 81°09'50"
L10	8.7 km east of Port Stanley (Lewison's Gully)	42°39'42", 81°06'24"
L11	Port Bruce	42°39'25", 81°01'22"

Appendix III: Sites sampled with seine nets to document the occurrence of juvenile walleye in the central basin, Lake Erie, 1985.

Site	Site location	Latitude/longitude	Substrate type[a]
S1	Patrick Point - west of stream mouth	42°35'04", 81°28'00"	Gravel, rubble
S2	Tyrconnell - 100m east of stream mouth	42°35'42", 81°27'33"	Sand, gravel, rubble
S3	Plum Point - 150m west of stream mouth	42°36'20", 81°24'00"	Sand, gravel, rubble, boulders
S4	Port Talbot - 100m west of mouth of Talbot Creek, near red storage shed	42°38'16", 81°21'21"	Sand, gravel
S5	Port Stanley - near west boundary of public beach	42°39'35", 81°13'07"	Sand, gravel
S6	Elgin Area Water Pumping Station - 50m west of pumping station	42°39'44", 81°09'43"	Sand, gravel, rubble
S7	Port Bruce - opposite changehouses at Port Bruce Provincial Park	42°39'14", 81°00'42"	Sand, gravel

[a] Rubble size range is 7.6 - 25.4 cm, gravel size range is 0.2 - 7.6 cm, sand size range is less than 0.3 cm (Dodge et al 1984).

Appendix IV: Sites sampled with a trawl to document the occurrence of juvenile walleye in the central basin, Lake Erie, 1985.

Site	Site location	Latitude/longitude
T1	Port Talbot	42°38'18", 81°21'18"
T2	Port Stanley	42°39'35", 81°13'47"
T3	Elgin Area Water Pumping Station	42°39'44", 81°09'43"
T4	Port Bruce	42°39'14", 81°00'42"

Appendix V: Comments made by Ministry of Natural Resources personnel and commercial fishermen concerning walleye spawning in the central basin of Lake Erie, 1985.

Comments made by Ministry of Natural Resources personnel and commercial fishermen concerning the spawning run of walleye in the central basin of Lake Erie in the spring of 1985 included:

- on April 27, a "ripe and running" female walleye was seen on one of the boats fishing in grid 2266;
- on April 29, one of the fishermen landed 544 kg of small walleye from grid 2265. He claimed to have seen only 4 or 5 large walleye and these he discarded. He said that the female walleye were "hard" when he pulled his nets the previous week. The fisherman claimed to have seen "lots" of large walleye earlier in the spring when he was fishing on the bottom;
- on April 29 the catches of several other boats were examined for large walleye. One catch contained three large walleye from grid 2277, two of which were spent and the other ripe. Another catch contained one spent female walleye from grid 2275;
- on May 1, a fisherman landed 236 kg of small walleye and the ovaries from six large female walleye caught in grid 2255. All of the ovaries had come from fish that weighed from 2.7 to 4.1 kg. Five of the ovaries were spent and the other was ripe;
- a fisherman claimed to have caught large female walleye with "running" eggs in the Patrick Point-Plum Point and Port Bruce areas during the spawning season;
- several fishermen commented that there were few large walleye (in "canned" nets) during the spawning season and the ones that were being caught were not being landed. These fishermen suspected that the larger walleye would become more abundant as the water

temperature increased;

- other fishermen admitted they were catching but not landing large numbers of large walleye;
- throughout the period of the study, there were reports by Ministry of Natural Resources personnel and others of large walleye not being landed during the spawning season. Actual numbers of walleye not being landed and their proportion of the total catch are not known.